Annual Progress Report

Acid Mine Drainage Pollution Abatement Feasibility Study

Belt-Galena Hughesville, Montana

April 1974

ACID FORMATION

The natural geologic deposits of iron disulfides (FeS_2) are usually found in the crystalline form as pyrite or marcasite. These deposits can be found in varying amounts in many metal ore and coal deposits. In the Hughesville spoil piles and abandoned mine shafts the disulfides are exposed to oxygen and water causing them to decompose, as illustrated in Equation 1:

$$2FeS_2 + 2H_2O + 7O_2 \rightarrow 2FeSO_4 + 2H_2SO_4 \qquad (1)$$

Pyrite + Water + Oxygen ⟶ Ferrous Sulfate + Sulfuric Acid

The ferrous sulfate product from this reaction can be oxidized to ferric sulfate by chemical or biological reactions as in Equations 2 and 3.

$$4FeSO_4 + O_2 + 2H_2SO_4 \rightarrow 2Fe_2(SO_4)_3 + 2H_2O \qquad (2)$$

$$2FeSO_4 + O + H_2SO_4 \xrightarrow{\text{bacteria}} Fe_2(SO_4)3 + H_2O \qquad (3)$$

The bacteria referred to in Equation 3 are Thiobacillus ferrooxidans. These bacteria accelerate oxidation of the ferrous ion.

The ferric sulfate produced can then serve as an oxidizing agent, oxidizing additional sulfides, represented by Equations 4.

$$Fe_2(SO_4)_3 + FeS_2 \rightarrow 3FeSO_4 + 2S \qquad (4)$$

The elemental sulfur released can be utilized by the bacteria Thiobacillus thiooxidans as an energy source producing more acid with the reaction illustrated in Equation 5.

$$S + 3O + H_2O \xrightarrow{\text{bacteria}} 2H^+ + SO_4^= \qquad (5)$$

The ferric sulfate produced, (Equations 2 and 3), can also be hydrolyzed to form sparingly soluble ferric hydroxide and release additional acid.

$$Fe_2\ (SO_4)_3 + 6H_2O \rightarrow 2Fe(OH)_3 + 3H_2SO_4 \qquad (6)$$

Separately or in combination, chemical or bacterial oxidation indicated by these reactions produces acidic water. The acidic water usually flows through geological materials, dissolving minerals to varying degrees, thereby adding constituents to the stream load.

Mine drainage is not always acidic. In some cases, probably due to low sulfide concentration, the drainage resembles ground water found outside the affected area.

EFFECT ON STREAMS

The effect of discharging acid mine waste into a stream is dependent on the relative flow in the two streams. Usually (and very evident in Galena Creek) the acid waste produces a characteristic yellow-orange precipitate, (iron hydroxides) some of which settles. The alkalinity of the receiving stream decreases, while the iron and sulfate concentration increases. If the stream contains sufficient alkalinity to maintain a pH above 4.5, most of the iron is precipitated. In the case where sufficient alkalinity is not present in the receiving stream to maintain this pH, hydrolysis of ferric sulfate can occur, increasing the acidity (1).

The native aquatic plants and animals normally found in unpolluted streams are nonexistent in a stream polluted with a heavy load of acid mine drainage.* The heavy metal loadings and acidity of the Galena Creek flow, make the water impottable to the wildlife in the area.

STUDY AREA

The Hughesville Galena Creek Acid Mine Drainage Study area is located 12 miles east of the community of Monarch, which is on Highway 89, 40 miles southeast of Great Falls, Montana. This area is southeast of the Great Falls coal fields and is entirely within the Belt Creek Drainage Area. (see map on next page)

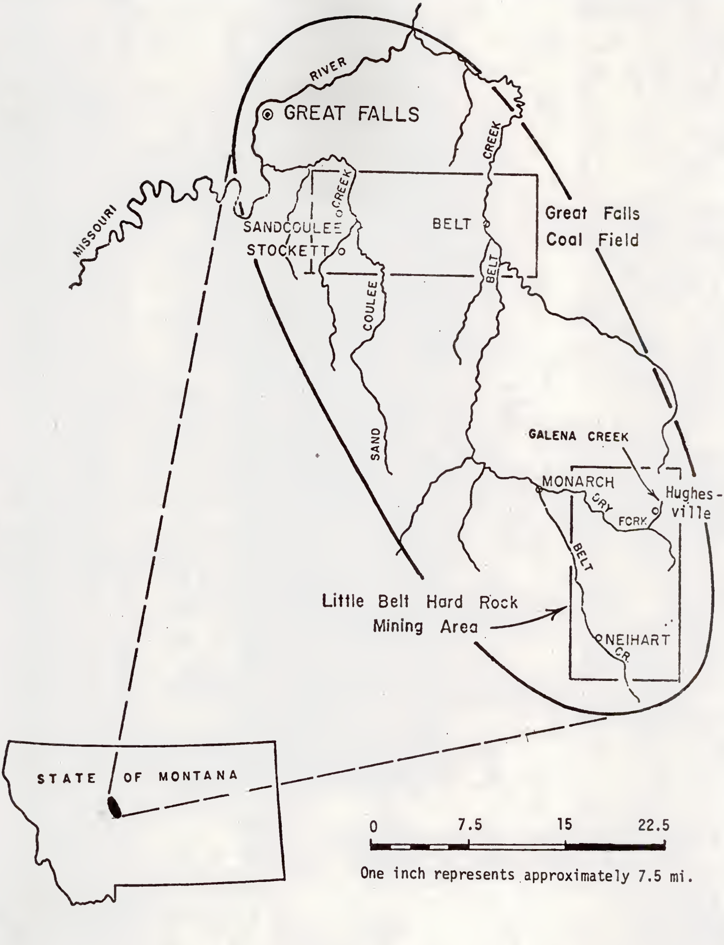
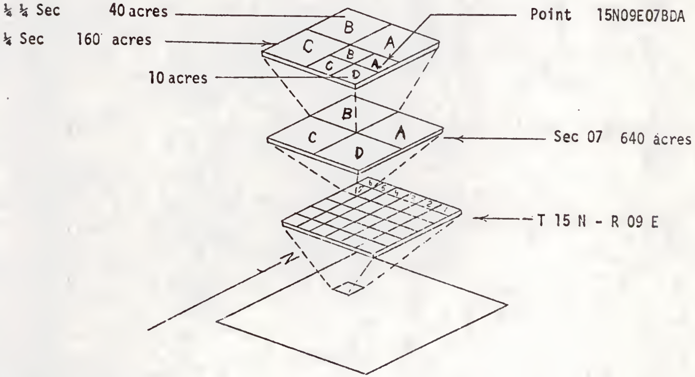


Figure 1. Index map showing location of Hughesville-Galena Creek Drainage Area

WATER QUALITY SAMPLING POINTS
STATIONS SAMPLED NOVEMBER 1973 - APRIL 1974

Number	Station	Location		
DF 1.	GALENA CK AT LOWER WEIR	15N	09E	18BC
DF 2.	SILVER CK AT ROAD ABOVE MOUTH	15N	09E	07BDB
DF 3.	LIBERTY MINE SEEP AT GALENA CK	15N	09E	07BDA
DF 4.	GALENA CK JUST BELOW MINE DUMP	15N	09E	07BAA
DF 5.	SPRING ALONG GALENA CK IN MIDDLE OF MINE CARS	15N	09E	07BAA
DF 7.	GALENA CK AT UPPER WEIR	15N	09E	06DCB
DF 8.	GALENA CK AT HARRISON MINE, ABOVE GREEN CK INFLUX	15N	09E	06DB
DF29.	DRY FK 25 YDS ABOVE MOUTH	15N	07E	04AAA
DF31	BELT CK 10 YDS ABOVE DRY FORK	15N	07E	04AAA



WATER QUALITY SAMPLING POINTS

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DF 4.	GALENA CK JUST BELOW MINE DUMP	15N	09E	07BAA
DF 5.	SPRING ALONG GALENA CK IN MIDDLE OF MINE CARS	15N	09E	07BAA
DF 6.	BUBBLING SPRING AT BLOCK P MINE	15N	09E	06DCC
DF 7.	GALENA CK AT UPPER WEIR	15N	09E	06DCB
DF 8.	GALENA CK AT HARRISON MINE, ABOVE GREEN CK INFLUX	15N	09E	06DB
DF 9.	CAVED TUNNEL OUTFLOW (MOULTON MINE) ON GALENA CK	15N	09E	06BD
DF10.	GALENA CK ABOVE CAVED TUNNEL	15N	09E	06DBA
DF11.	GREEN CK ABOVE TRIBUTARY	15N	09E	06BD
DF12.	CARTER MINE TUNNEL DRAINAGE ALONG GREEN CK	15N	09E	06BD
DF13.	TRIBUTARY TO GREEN CK ABOVE MINE DRAINAGE INFLOW	15N	09E	06BD
DF14.	GREEN CK ABOVE MOUTH AT GALENA CK	15N	09E	06DBC
DF15.	DAISY CK ABOVE GALENA CK	15N	09E	06DCB
DF16.	QUEEN OF THE HILLS CK AT MOUTH ON GALENA CK	15N	09E	06DCC
DF17.	SILVER CK ABOVE MINE SEEP	15N	09E	07BB
DF18.	MINE SEEP ABOVE SILVER CK	15N	09E	07BB
DF19.	BEND GULCH CK JUST ABOVE GALENA CK	15N	09E	07CAC
DF20.	GOLD RUN CK AT BR AT CASCADE/JUDITH BASIN CO LINE	15N	09E	18CBBC

DF21.	GALENA CK 150 YDS ABOVE MOUTH	15N	08E	13DCD
DF22.	DRY FK BELT CK AT ROAD CROSSING ABOVE GALENA CK	15N	08E	13DCD
DF23.	DRY FK BY CABIN 100 YDS E OF MISSILE SITE (9.75 MI FROM HWY 89)	15N	08E	23AAB
DF24.	DRY FK ABOVE FINN CK 7.95 MI FROM HWY 89	15N	08E	16DBD
DF25.	DRY FK AT BRIDGE 5.95 MI FROM HWY 89 (BRIDGE NO. 9)	15N	08E	08DBB
DF26.	DRY FK AT BRIDGE 2.0 MI FROM HWY 89 (BRIDGE NO. 3)	15N	07E	02AAA
DF27.	DRY FK AT CAMPGRND BELOW CASTLE ROCK 1.3 MI FROM HWY 89	15N	07E	02BAC
DF28.	DRY FK AT BRIDGE 0.7 MI FROM HWY 89 (BRIDGE NO. 2)	15N	07E	03ABD
DF29.	DRY FK 25 YDS ABOVE MOUTH	15N	07E	04AAA
DF30.	BELT CK 20 YDS BELOW DRY FORK	16N	07E	33DDD
DF31.	BELT CK 10 YDS ABOVE DRY FORK	15N	07E	04AAA
DF32.	BELT CK JUST ABOVE NEIHART	13N	08E	05B

ANNUAL REPORT

Report Period: March 15, 1973 - April 15, 1974

Submitted to

the

ENVIRONMENTAL PROTECTION AGENCY

BY

STATE OF MONTANA

Department of Natural Resources and Conservation

on

STUDIES CONCERNING

ACID MINE DRAINAGE

STREAM POLLUTION ABATEMENT

NEAR HUGHESVILLE, MONTANA

MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

Progress Report No. 13
Grant No. S-802122, Hughesville

TABLE OF CONTENTS

PROJECT PERSONNEL

Bondy, Richard L. , C.E.
Water Resources Division
Department of Natural Resources and Conservation
Project Manager (Effective March 21, 1974)

Ferris, Orrin A., P.E.
Water Resources Division
Department of Natural Resources and Conservation
Project Manager, (March 1973 - March 21, 1974)

Botz, Maxwell K., P.E.
Department of Health and Environmental Sciences
Head of Planning and Surveillance

Jankowski, Walter A.
Department of Health and Environmental Sciences
Supervisory Water Quality Chemist

Stevenson, Robert K.
Cascade City-County Health Department
Field Investigator and Stream Gage Operator

Siroky, Laurence J., Ag. E.
Water Resources Division
Department of Natural Resources and Conservation
Project Supervisor and Design Engineer

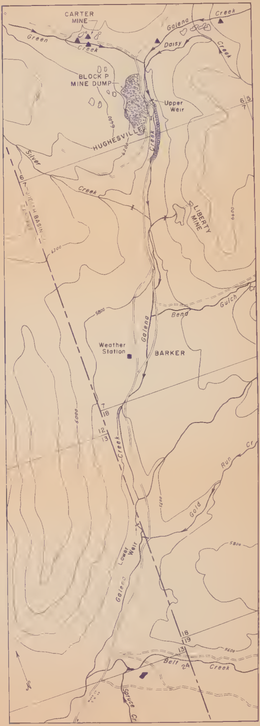
Smith, Robert W., C.E.
Water Resources Division
Department of Natural Resources and Conservation
Project Coordinator and Progress Report Composer

INTRODUCTION

THE CHEMISTRY AND BIOLOGY OF ACID MINE DRAINAGE

Acid Mine Drainage problems, many similar to the stream pollution problem in Galena Creek near Hughesville, Montana, have long been a subject of intensive study. No two Acid Mine Drainage problems have the same solution because of the innumerable variables such as local terrain and land use, and local economic factors such as availability of treatment equipment and supplies. Unfortunately, due to the variability of the geologic makeup of the study areas, a complete explanation of the processes has not been formulated. The general relationship of most variables involved in the mechanisms of Acid Mine Drainage formation, however, have been established with general agreement (1, 2, 3, 4, 5). The following, though quite brief, is the generally accepted description of the mechanisms of Acid Mine Drainage formation, along with consideration of effects on receiving streams.

A map showing the location of Hughesville is found on page six and a detailed map of the study area follows.



PLAN AND TOPOGRAPHIC MAP
DRY FORK BELT CREEK

APRIL 1974, T 15N - R 9E

- COUNTY LINE
- IMPROVED ROAD
- UNIMPROVED ROAD
- MINE WORKINGS
- BLOCK P MINE DUMP
- WEATHER STATION
- WATER QUALITY SAMPLING POINT
- STREAM GAGING RECORDER
- PERENNIAL STREAM
- PROPOSED UNDERGROUND DIVERSION PIPELINE

SCALE

Objectives

The primary objective of the Hughesville Acid Mine Drainage Feasibility Study is to determine the influences of the acid mine water on the various systems in the Belt Creek drainage areas which are affected by the acid mine water and to formulate an approach to minimize the adverse affects of the mine drainage problem.

In order to attain this objective, it has been necessary to apply investigative effort toward:

The identification of the natural geological and hydrological systems within the study area and to define their control over the formation and transportation of acid mine waters.

The development and evaluation of possible techniques for effective improvement of present water quality and prevention of any further contamination.

The recommendation of the technique which provides the most beneficial, permanent, and economical results.

Pipeline

The diversion pipeline (to be installed in June) is intended as a means of transporting the uncontaminated main flow of Galena Creek around the Block P tailing area. By by-passing the tailing area of the Block P Mine, the seepages which are the major sources of the pollution problem can be isolated. A major problem, that of having too large a flow to be harnessed for any sort of treatment, may be solved by isolating the most contaminating seepages.

Work Progress: Summary of Activities Throughout Annual Report Period

Water Quality samples were taken and analyzed and field inspections were made monthly throughout the report period.

February 1973 - Prefeasability study data was accumulated and the Grant Agreement for the Hughesville Acid Mine Drainage Feasibility Study was drafted by the EPA. Henry C. Steed, Jr. signed the grant agreement for the EPA on February 28, 1973.

March 1973 - The grant agreement was recieved and reviewed by the Department of Natural Resources and Conservation and signed for the Department by Gary J. Wicks on March 27, 1973. March 15, was designated by the EPA as the project starting date.

April 10, 1973 - A project orientation and organizational meeting was held with involved and interested parties for the purpose of initiating the feasability study as a cooperative effort.

May 1973 - Site examination and field inspections were made by the EPA representatives, mine owners, Departmental employees, and other agency personnel, and concerned individuals. Water quality sample collection and chemical analysis were initiated. Most of the project equipment was ordered, and base maps were prepared from aerial photos.

June 1973 - The first monthly weather station records were obtained and two weirs for recording stations were constructed and installed.

July 1973 - Flow measurements and sample collections were made on all potential sites of acid mine drainage in order to trace the various acid mine point influences on Galena Creek from the Hughesville drainage area.

August 1973 - Field work continued, consisting of the installation of two Cippoletti weirs and gage houses to be used as stilling wells for two Type A-71 recorders, and taking water quality samples. Lime neutralization studies were conducted.

September 1973 - Three (3) Parshall Flumes and three Type F Recorders were installed and the diversion pipeline to be installed in the spring was surveyed for cross-sections and grade determination.

October 1973 - The fall work schedule was completed, and sampling, analytical work and water level monitoring continued.

Work Progress: (Con't)

November 1973 - Type F continuous recorders were rendered inoperative by excessive ice build-up until reactivation at the Spring thaw.

The Lab was set up to facilitate extended aeration and neutralization tests.

A project progress and planning meeting was held and attended by representatives of the Bureau of Mines and Geology, Department of Health and Environmental Sciences, Forest Service, and Water Resources Division to discuss the present work status and to make preparations for the increased spring activity.

December 1973 - Extensive treatability tests were run in the lab including: natural aeration tests (to similate a settling pond), forced aeration test (to similate turbid water or air forced through water), and lime neutralization tests.

The diversion pipeline design was revised by relocation of the pipeline in an established road rather than in the stream bed to avoid unnatural disturbance of the stream bed.

January 1974 - The revised hydraulic design for the diversion pipeline which will carry the uncontaminated main flow of Galena Creek past the Block P Mine spoil piles, has been completed. Right of Way Easements were obtained for the pipeline.

The process of collecting winter base flow continued, although hampered somewhat because of limited accessability by deep snow and monitoring difficulties due to ice build-up.

February 1974 - The residual heavy metals analysis for the January samples was completed. Water quality samples were taken at 7 regular stations which had flow plus the mouth of Dry Fork and Belt Creek above the Dry Fork.

March 1974 - A rough draft of the Annual Report was completed. Close surveilance was maintained over the study area watching for initial phases of spring runoff.

April 1974 - The Type F continuous recorders were reactivated in order to monitor the spring runoff.

Solution Proposal

In order to achieve a solution to the Hughesville Acid Mine Drainage Polution Problem, there are two major stream (Galena Creek) conditions which must be modified.

Flow Volume

Excessive flow volume in Galina Creek to be practicably harnessed for any treatment has been a primary consideration in the Pollution Abatement Feasibility Study.

The necessary flow modification has been achieved in design by the construction of an underground pipeline which will carry the relatively uncontaminated main flow of Galena Creek past the most detramental seepages. These seepages, which are the most damaging are in the area of the Block P Mine Tailings Dump. (detailed map-page 7)

The pipeline which will be constructed in June is 1,150 feet long, 12" PVC. It has been designed to accommodate the average annual maximum discharge of Galena Creek (10 cfs) which usually occurs during spring runoff. The inlet structure is designed such that an unusually high discharge will, without damage, overflow into the natural streambed of Galena Creek at the point of the inlet structure.

Acidity

Another condition which must be resolved before any proposed physical treatment can be effective is the extreme acidity (low pH) in Galena Creek. This acidity prevents the precipitation of critical levels of zinc, copper, and manganese.

The excessive acidity of Galena Creek will most likely be relieved by a preliminary treatment with limestone which is very abundant in the area. It will be necessary to affect a pH of 4.5 or higher so that precipitation of residual metals will effectively occur.

AERATION AND SETTLING STUDIES

On November 28, 1973, samples were collected at seven of the major sites along Galena Creek, the Block P Mine spring having shown no flow since September. Three additional samples bottles per site were filled at five of the sites, refrigerated, and used for settling and aeration studies.

Settling Study Procedure:

Two sample bottles from each site were uncapped and loosely covered with foil to allow evaporation to occur. They were stored at room temperature in the laboratory (25° C). After one week of settling, water was decanted from one of the bottles from each site, filtered through a 0.45 u filter, and analyzed immediately for dissolved iron, manganese, zinc, and copper.

After standing for four weeks, water from the remaining bottles was decanted, filtered, and analyzed for the same constituents.

Aeration Study Procedure: (Figure 1, Page 16)

Air was drawn through the samples for one week, using the apparatus shown in figure 1. Flow rate was 1.25 liters per minute. To minimize the effect of water carryover as the air passes from one sample to another, the bottles were arranged in ascending order of metal concentrations: DF 7, DF 1, DF 2, DF 4, DF 5.* As with the settling-study samples, water was decanted after one week of aeration, filtered, and run for dissolved iron, manganese, zinc, and copper.

Results:

The results are summarized in Table 1. Iron was essentially removed from solution in those samples where pH was 4.80 or higher. Zinc showed a reduction upon settling, possibly due to co-precipitation with, or adsorption on, the iron precipitate. Copper and manganese were essentially unchanged by these treatments.

These results seem to indicate that none of the experimentally tested physical treatments will be effective without a preliminary pH modification. The physical treatments being considered are; collecting, ponding and settling; collecting, ponding and aerating, and a combination of both settling and aeration. (results on next page)

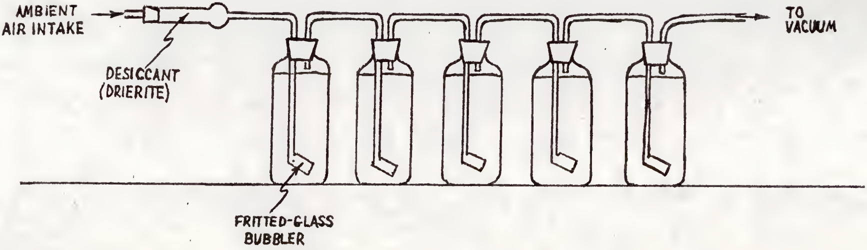
*Station code numbers: see listing of sampling points for descriptions of these sites.

TABLE 1. EFFECTS OF SETTLING AND AERATION ON METAL CONCENTRATIONS

	Site				
	DF 1	DF 2	DF 4	DF 5	DF 7
Initial pH	4.80	3.60	5.50	2.92	7.75
Iron, dissolved (mg/l					
Original sample	3.3	2.7	16	210	0.0
1-week settling	0.0	2.0	0.0	140	0.0
4-week settling	0.0	2.2	0.0	123	0.0
1-week aeration	0.0	1.8	10	120	0.0
Zinc, dissolved (mg/l					
Original sample	20	15	15	105	.22
1-week settling	20	11	13	105	.16
4-week settling	13	7.2	8.8	75	*
1 week aeration	20	11	*	106	.15
Manganese, dissolved (mg/l					
Original sample	18	7.0	9.8	113	.09
1-week settling	17	6.7	9.8	113	.08
4-week settling	17	5.8	9.0	113	.10
1-week aeration	18	6.7	*	89	.10
Copper, dissolved (mg/l					
Original sample	.32	.18	.15	3.2	.01
1-week settling	.31	.18	.16	2.8	.01
4-week settling	.25	.14	.14	3.0	.01
1-week aeration	.28	.18	*	1.6	.01

* Rejected data: reported values exceeded those in original sample by a factor of 3 or greater

FIGURE 1. EXPERIMENTAL APPARATUS
FOR AERATION STUDY



NEUTRALIZATION STUDIES

On August 21, 1973, a sampling run was made at eight sites along Galena Creek. Duplicate samples were collected at these sites, refrigerated, neutralized in the lab, and analyzed for selected residual heavy metals: iron, manganese, zinc, and copper. The original and residual concentrations, and quantities of base required for neutralization are listed on the following chart.

Neutralization procedure: A 300 ml. aliquote of sample was titrated with 0.10 N sodium hydroxide to a pH 11 endpoint. Samples were stirred continuously; pH readings were made one minute after adding each increment of base. A final reading was made 15 minutes after the last base addition. An altered procedure was used for the mine-seep samples: After pH 11 was reached, 1 ml. of 30 percent hydrogen peroxide was added to convert most of the remaining ferrous-iron to the ferric form. Additional base was added to return the pH to 11, and a final reading made after a 15-minute period.

The neutralized samples were filtered, acidified, and run for dissolved metals.

NEUTRALIZATION STUDY DATA

	SAMPLING SITE								
	1	3	4	5	6	7	8	16	2
Field pH	3.8	2.8	4.4	2.7	2.9	8.2	7.7	3.8	NOT FLOWING
Field Temp., ^{o}C	19.2	15.7	13.5	8.0	9.5	11.0	9.5	10.6	
ppm Fe (initial)	1.4	200	15	280	320	.05	.01	.01	
ppm Fe (final)	.05	.01	.20	.01	.01	.01	.01	.01	
ppm Zn (initial)	18	108	14	125	73	.14	.75	1.0	
ppm Zn (final	.02	.01	.19	.03	.03	.01	.01	.03	
ppm Cu (initial)	.32	1.5	.13	3.3	.40	.01	.01	.01	
ppm Cu (final)	.01	.01	.01	.01	.01	.01	.01	.01	
ppm Mn (initial)	23	275	20	130	210	.13	1.0	.25	
ppm Mn (final)	.01	.01	.51	.01	.03	.01	.01	.05	
ml. NaOH used	13.9	92.1	13.2	113.1	103.2	6.8	7.1	4.2	
$CaCO_3$ equivalence of base - mg/l	231	1536	220	1886	1721	113	118	70	
pH after H_2O_2	9.9	9.7	--	10.2	9.4	--	--	--	
Additional ml. NaOH	3.1	8.4	--	6.1	13.9	--	--	--	
TOTAL BASE USED in mg/l $CaCO_3$)	284	1676	220	1988	1953	113	118	70	
pH after last tit'n.	11.2	11.0	11.0	11.0	11.1	11.1	11.0	11.0	
pH after 15 minutes	11.2	10.8	10.9	10.9	11.0	11.1	11.0	11.0	

ANALYTICAL EQUIPMENT AND SUPPLIES PURCHASED

Date Received (Quarter)	Equipment & Supplies
June - September, 1973	Stirrer for jar testing Portable pH meter Conductivity cell Beakers, 1,000ml pH meter pH electrode
October - December, 1973	Mho meter Automatic Sampler Sampler bottles carrying case
January - March, 1974	Conductivity Bridge Continuous Recording Conductivity meter

Weather Station

An evaporation-weather station was installed in the area in June. The station consists of an evaporation pan, maximum-minimum air and water thermometers, rain gage and totalizing anemometer. The station has been and is currently being operated by Mrs. Gwen McBride, a local observer. Records obtained monthly from Mrs. McBride are submitted to the analytical division of the Department of Health and Environmental Sciences for use as a data interpretational aid.

Waste Loads

Of particular concern are waste loadings of copper, zinc, iron, cadmium, and manganese. A summary of loadings since August, 1973 and graphs of concentration since project inception follow. (Prior loadings are listed in October 18, 1973 quarterly report.)

Note: Loads calculated by:

Load (pounds/day)=concentration (mg/l) x flow (cfs) x 5.39
(or)
Load (pounds/day)=concentration (mg/l) x flow (gpm) x 0.012

IRON LOADS in pounds/day
[Quantities are dissolved unless labeled (T): total recoverable]

Date

Station	9/6/73	10/3/73	11/5/73	11/28/73	1/18/74	2/28/74		
DF 1	*	**	*	8.4	44.0(T)	*		
DF 2	*	*	0.46(T)	0.16	*	*		
DF 3	*	6.9(T)	7.9(T)	0.004(T)	*	*		
DF 4	*	*	*	34.5	*	*		
DF 5	*	33.4(T)	27.8(T)	17.6	*	*		
DF 6	*	not flowing	not flowing	not flowing	not flowing	not flowing		
DF 7	*	1.1	*	0[.28(T)]	0.31(T)	*		
DF 8	*	**	*	0.67(T)	*	*		

*load can't be calculated; no flow data available
**not sampled

CADMIUM LOADS in pounds/day
[Quantities are dissolved metals unless labeled (T): total recoverable]

Station	9/6/73	10/3/73	11/5/73	11/28/73	1/18/74	2/28/74		
DF 1	*	**	*	**	**	*		
DF 2	*	*	**	**	*	*		
DF 3	*	0.012(T)	**	**	*	*		
DF 4	*	*	*	**	*	*		
DF 5	*	0.07(T)	**	**	*	*		
DF 6	*	not flowing	not flowing	not flowing	not flowing	not flowing		
DF 7	*	<0.03	*	**	*	*		
DF 8	*	**	*	**	*	*		

*load can't be calculated; no flow data available
**not sampled

COPPER LOADS in pounds/day
[Quantities are dissolved metals unless labeled (T): total recoverable]

Station	9/6/73	10/3/73	11/5/73	11/28/73	1/18/74	2/28/74		
DF 1	*	**	*	0.82	1.74(T)	*		
DF 2	*	*	0.004(T)	0.01	*	*		
DF 3	*	0.05(T)	0.06(T)	0.005(T)	*	*		
DF 4	*	*	*	0.32	*	*		
DF 5	*	0.68(T)	0.39(T)	0.27	*	*		
DF 6	*	not flowing	not flowing	not flowing	not flowing	not flowing		
DF 7	*	0.08	*	<0.02	<0.03(T)	*		
DF 8	*	**	*	0.03(T)	*	*		

*load can't be calculated; no flow data available
**not sampled

MANGANESE LOADS in pounds/day
[Quantities are dissolved metals unless labeled (T): total recoverable]

	Date							
Station	9/6/73	10/3/73	11/5/73	11/28/73	1/18/74	2/28/74		
DF 1	*	**	*	46	11.1(T)	*		
DF 2	*	*	0.37(T)	0.42	*	*		
DF 3	*	8.2(T)	8.6(T)	0.6(T)	*	*		
DF 4	*	*	*	21.1	*	*		
DF 5	*	17.3(T)	13.4(T)	9.5	*	*		
DF 6	*	not flowing	not flowing	not flowing	not flowing	not flowing		
DF 7	*	0.43	*	0.16	0.20(T)	*		
DF 8	*	**	*	0.38(T)	*	*		

*load can't be calculated; no flow data available
**not sampled

ZINC LOADS in pounds/day
[Quantities are dissolved metals unless labeled (T): total recoverable]

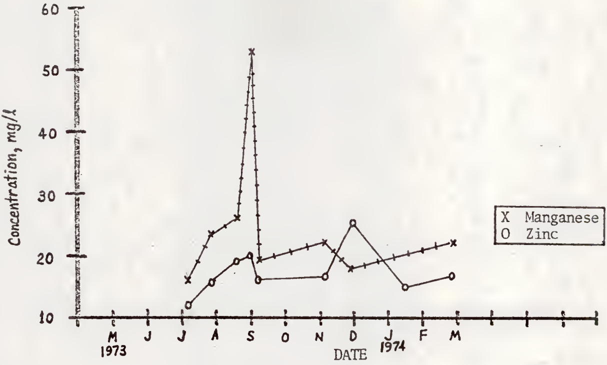
	Date							
Station	9/6/73	10/3/73	11/5/73	11/28/73	1/18/74	2/28/74		
Galena Creek at Lower Weir DF 1	*	**	*	51.1	72.6(T)	*		
Silver Creek at road DF 2	*	*	0.51(T)	0.9	*	*		
Liberty Mine seep DF 3	*	0.36(T)	3.3(T)	0.31(T)	*	*		
Galena Creek below dump DF 4	*	*	*	32.3	*	*		
Spring in Creek DF 5	*	23.0(T)	13.0(T)	8.8	*	*		
Block P Spring DF 6	*	not flowing	not flowing	not flowing	not flowing	not flowing		
Galena Creek at upper weir DF 7	*	0.66	*	0.38	0.51(T)	*		
Galena Creek at Harrison mine DF 8	*	**	*	1.1(T)	*	*		

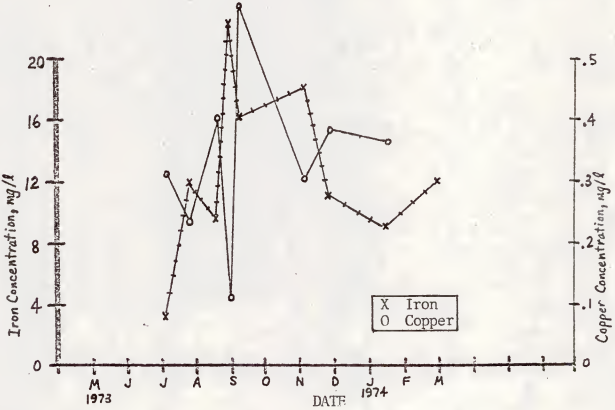
*load can't be calculated; no flow data available

**not sampled

CONCENTRATION DATA
(Conc. Are Total Recoverable)

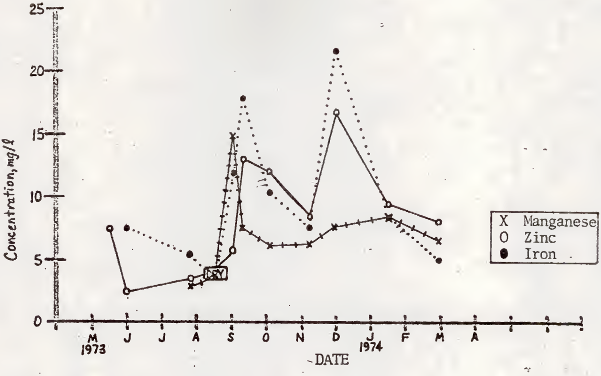
DF 1 GALENA CREEK AT LOWER WEIR

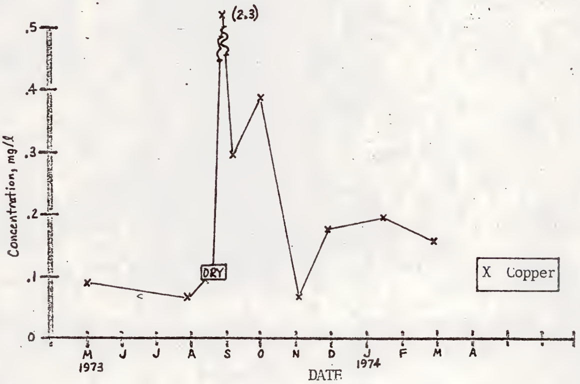




CONCENTRATION DATA
(Total Recoverable)

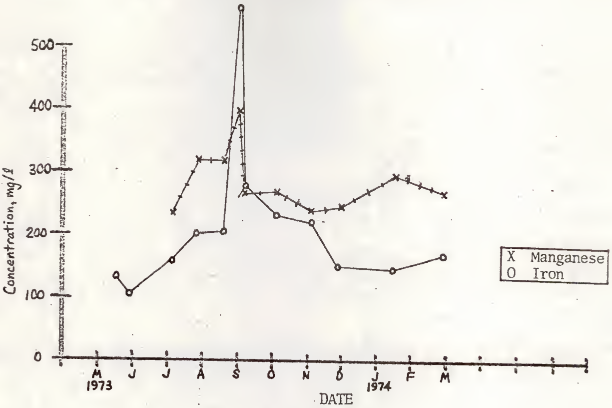
DF 2 SILVER CREEK AT ROAD ABOVE MOUTH

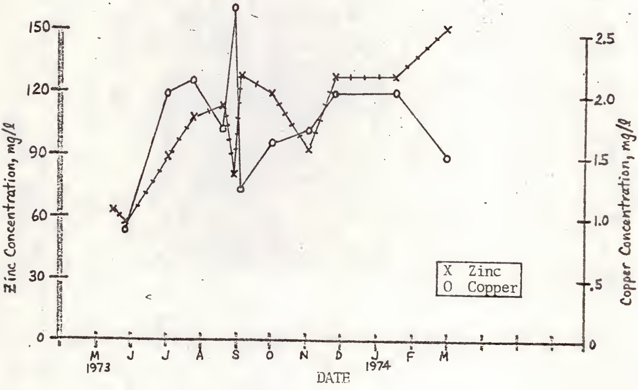




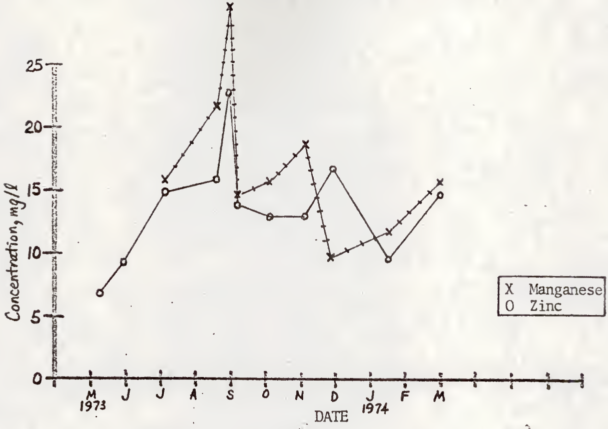
CONCENTRATION DATA
(Total Recoverable)

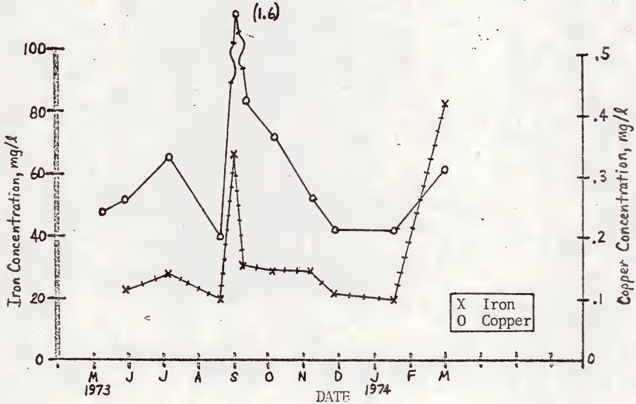
DF 3 LIBERTY MINE SEEP AT GALENA CREEK





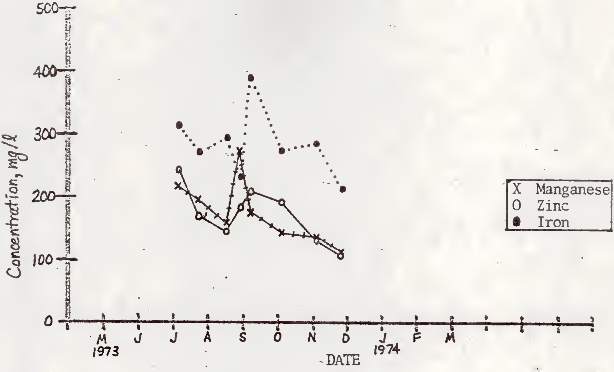
CONCENTRATION DATA
(Total Recoverable)
DF 4 GALENA CREEK JUST BELOW BLOCK P MINE DUMP

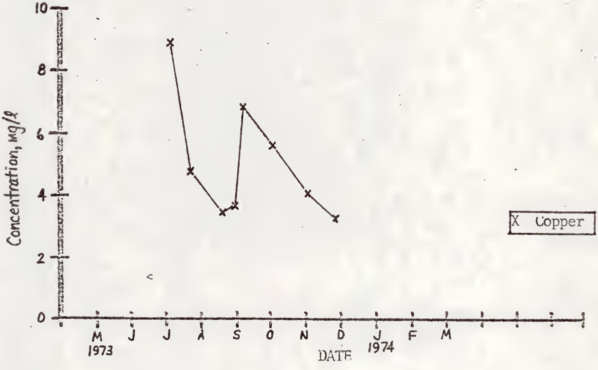




CONCENTRATION DATA
(Total Recoverable)

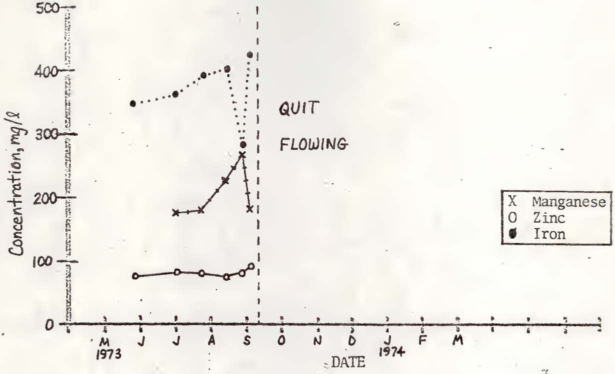
DF 5 SPRING ALONG GALENA CREEK IN MIDDLE OF MINE CARS

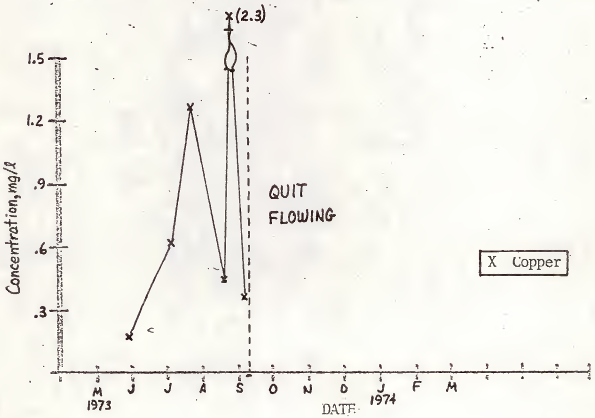




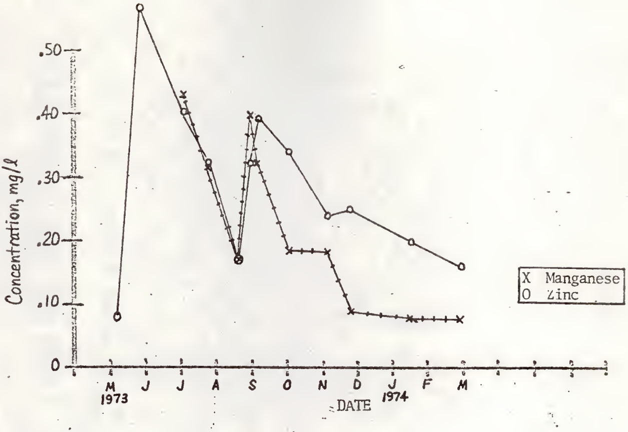
CONCENTRATION DATA
(Total Recoverable)

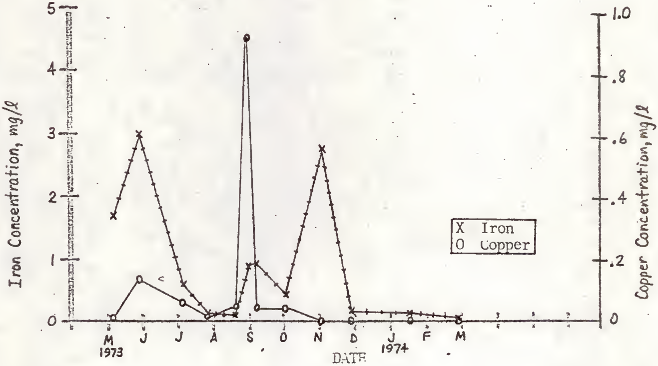
DF 6 BUBBLING SPRING AT BLOCK P MINE





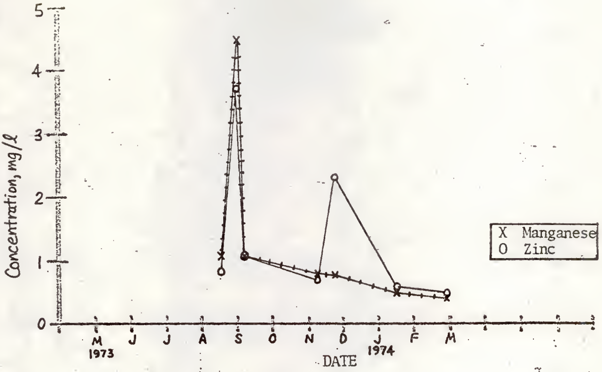
CONCENTRATION DATA
(Total Recoverable)
DF 7 GALENA CREEK AT UPPER WEIR

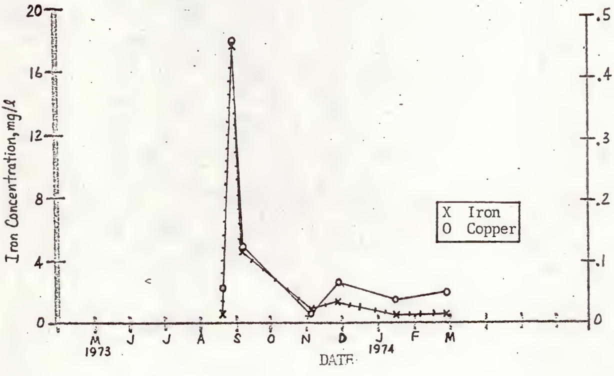




CONCENTRATION DATA
(Total Recoverable)

DF 8 GALENA CREEK AT HARRISON MINE ABOVE GREEN CREEK





REFERENCES

*McArthur, George Morris (1970) "Acid Mine Waste Pollution Abatement, Sand Coulee."